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Affected by Coal Strip-Mine Drainage

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THE AQUATIC INSECTS, WITH EMPHASIS ON TRICHOPTERA, OF A COLORADO STREAM AFFECTED BY COAL STRIP-MINE DRAINAGE

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ABSTRACT. Benthic sampling was conducted year-round over a 2 year period (July 1975-June 1977) on Trout Creek, a mountain stream in northwestern Colorado, to assess the effects of coal mine drainage on the stream insect community. Samples were taken monthly from rubble riffles above and below drainage from unreclaimed mine spoils. Unexpectedly, aquatic insects exhibited similar mean density and biomass values at each site and accounted for at least 95% of the total benthic standing crop above and below the mine. The number of insect taxa was similar and diversity index values did not vary significantly between sites. However, the community structure of the two sites did differ. Certain taxa were most abundant at the upstream site (*Proctia hexameta* and *Lepidostoma moneta*), while others were more abundant at the downstream location (*Agapetus boulderensis*, *Glossosoma centrale*, and *Hydropsyche* spp.). The greatest difference between the two sites was the differential importance of Trichoptera. At the upper site, caddisflies accounted for 39% of the benthic density due to the abundance of four families (Lepidostomatidae, Glossosomatidae, Brachycentridae, and Hydroptilidae). Trichopterans accounted for 60% of the benthic density below the mine, due primarily to the abundance of Hydropsychidae, and especially Glossosomatidae. This study points to the importance of community structure analysis in assessing effects of changes in environmental conditions in stream systems.

The detrimental effects of drainage from mine spoils on aquatic life have been well documented in the East, where acid mine drainage from high-sulfur coal strip-mine spoils has been a major pollutant of streams (see e.g. Parsons 1968, Roback and Richardson 1969, Koryak et al. 1972, Tomkiewicz and Dunson 1977). However, little is known of the effects of drainage from the low-sulfur coal strip-mines in the West (Canton and Ward 1978). Coal has been extracted from the Edna Mine, adjacent to Trout Creek in northwestern Colorado, for approximately 30 years. With the increased importance of western coal, the effects of mine drainage on aquatic life should be elucidated. Research was undertaken to determine the effects of drainage from the Edna Mine on the aquatic insects of Trout Creek.

STUDY AREA. Trout Creek flows roughly south-north beginning in the Dunkley Flat-Tops area and entering the Yampa River west of Milner, Colorado. The two study sites were located on rubble riffles in a third order section of the stream. Site C2 (Fig. 1) was immediately above the Edna coal mine at an elevation of 2208 m. At this point the stream was relatively undisturbed as it left a narrow valley and entered a flood plain. The substratum was coarse rubble overlying sand and gravel. The creek was well shaded at this site with willows and alders. The lower site, C4, was 2 km downstream at an elevation of 2150 m. Site C4 was below drainage from unreclaimed mine spoils, where mining ceased approximately 30 years ago, and also received drainage from more recent mining activity. The substratum was similar to that of C2. The riparian vegetation was not as dense due to cattle grazing; the grasses and sparse willows provided little shade for the stream. In addition, some irrigation return water entered Trout Creek above this site.

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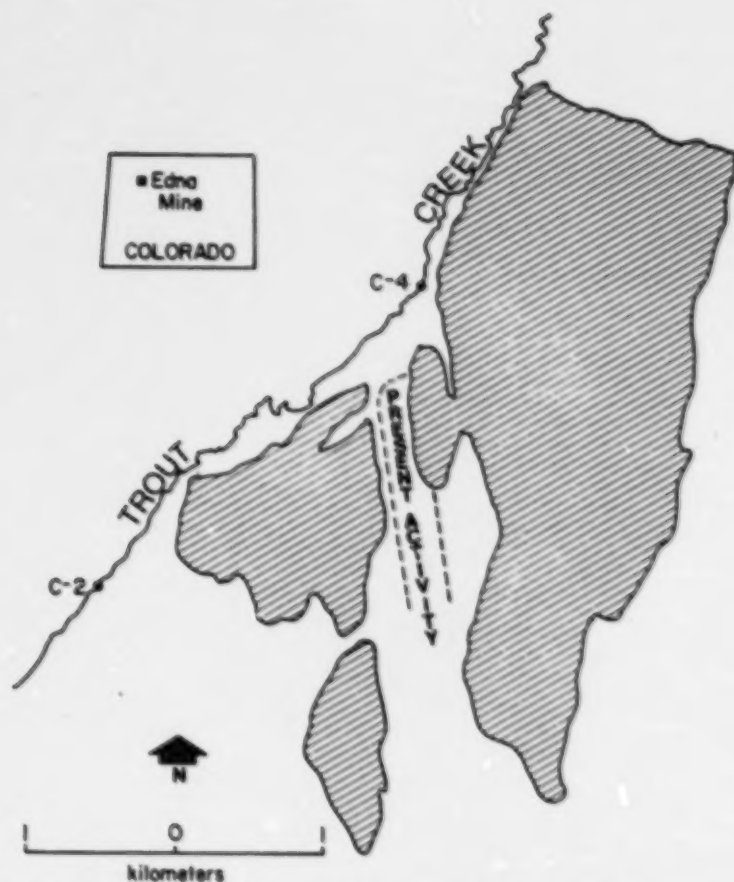


Fig. 1. Sampling stations and mine spoils (crosshatched) at Trout Creek, Colorado.

Selected water quality parameters for the two sites are presented in Table I. Since the mine spoils were located at least 30 m from Trout Creek, there was minimal input of suspended solids; the primary effect of mining was an increase in dissolved substances at C4. Alkalinity, specific conductance, total dissolved solids, and sulfate levels were all higher at C4. Stream temperature and pH were similar at the two sites. In the western U.S., overburden material from coal mining is generally low in pyritic materials and is quite shaley, accounting for its high buffering capacity (Ward et al. 1978). Thus, despite greater amounts of dissolved substances in the stream at C4, the pH is not depressed. The higher levels of sulfates below the mine drainage appear to be from gypsum ($\text{CaSO}_4 \cdot \text{H}_2\text{O}$) found in the overburden, rather than the oxidized sulfides from pyritic material found in acid mine drainage (McWhorter et al. 1973).

METHODS. Sites C2 and C4 on Trout Creek were sampled monthly from July 1973 through June 1977 (inclement weather precluded sampling C4 in January 1976). A Surber sampler which enclosed

TABLE 1. Mean values of selected water quality parameters for sites C2 and C4 on Trout Creek, Colorado, Oct. 1973 to Nov. 1976.* Values in parentheses denote number of samples.

Parameter	C2	C4
pH	7.7 (36)	7.8 (36)
Specific conductance (umhos/cm)	179 (36)	328 (36)
Alkalinity (mg CaCO ₃ /liter)	93 (36)	122 (15)
Total dissolved solids (mg/liter)	117 (32)	289 (12)
Sulfate (mg/liter)	13 (26)	83 (6)
Temperature (°C)	9.1 (24)	10.0 (24)

* from Skogerboe, et al. 1978.

929 cm² of substrate and equipped with a net with a mean mesh size of 700 μ m was used to collect five or six samples at each site. From January 1977 to June 1977, eight to 10 samples were taken monthly at each site with a modified Surber sampler (700 μ m mesh) which enclosed 0.04 m². The sampler has a screened front to reduce inflow of leaves and twigs and enclosed sides to reduce loss of organisms from backwash. The organisms collected were stored in 5% formalin, sorted from the debris, and placed in 80% ethanol for later identification and enumeration. Biomass (wet weight) was determined by volumetric displacement in a graduated centrifuge tube. The Shannon-Weaver Index was used to calculate species diversity. Statistical analysis of variance was calculated on log₁₀ transformations of the raw density data (organisms/sample) to allow use of parametric tests (Elliott 1973).

RESULTS AND DISCUSSION. Despite obvious differences in water quality, shading by riparian vegetation, and the degree of disturbance at the two sites, the aquatic insect communities appeared to be very similar. Mean total density and biomass of benthic invertebrates over 2 years exhibited similar values at C2 (3520 org m⁻²; 13.2 g m⁻²) and C4 (3024 org m⁻²; 12.0 g m⁻²) (Fig. 2), which did not differ significantly ($p > 0.05$). Unlike areas of acid mine drainage where stream insects are virtually eliminated (Roback and Richardson 1969), aquatic insects accounted for at least 95% of the total benthic density and biomass at both locations. The number of insect taxa was similar (52 at C2 and 50 at C4); 40 taxa were common to both sites. Median Shannon-Weaver Index values were also similar (3.3 for C2 and 3.4 for C4).

However, when the structure of the insect community was analyzed, the two sites began to diverge (Fig. 3). Only mayflies and beetles exhibited comparable relative abundance at both sites.

Ephemeroptera accounted for only 15% of the benthic density at C2 and 13% at site C4, in contrast to other studies in Colorado streams, where mayflies are the predominant members of the benthic community (Allan 1975; Ward 1975, 1976; Short and Ward 1979). Mayfly density at C2 was dominated by *Baetis* and *Rhithrogena*, while at C4, *Rhithrogena* was most abundant. *Rhithrogena* was also the most abundant mayfly in another Colorado mountain stream (Short and Ward 1979). The number of ephemeropteran species were similar with eight at C2 and seven at C4.

Coleopterans accounted for 16% of the benthic density at C2 and 13% at C4. The elmids beetles, *Optioservus seriatus* and *Zaitzevia parcula*, comprised virtually 100% of the coleopterans at both sites.

Plecopterans comprised 7% of the macroinvertebrates at C2 and 3% at C4, which is lower than values reported for similar sites on other streams in Colorado (Gray and Ward 1978, Short et al. 1978). Stoneflies were more numerous at C2 due to the abundance of *Triznaka signata* and especially *Prostoia besametsa*. There were also more plecopteran species at C2 (10) than at C4 (7).

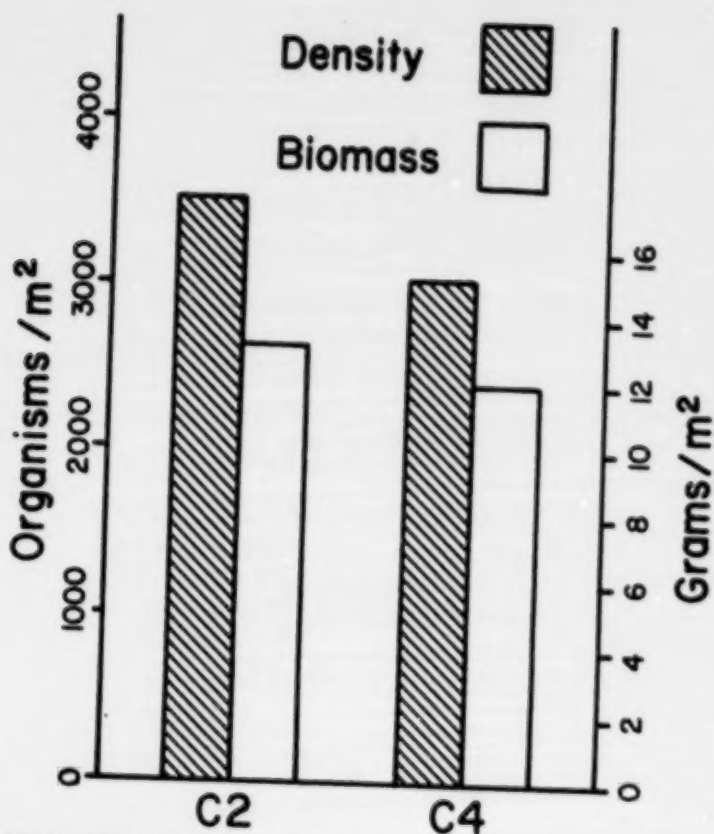


Fig. 2. Mean total macroinvertebrate density and biomass for sites C2 and C4 on Trout Creek, Colorado, over a 2 year period.

Dipterans were abundant at C2 (20%), but accounted for only 9% of the total density at C4. The value for C2 is similar to other values for Colorado streams (Gray and Ward 1978, Short and Ward 1979). Higher density of dipterans at C2 was due to the abundance of *Pericoma* and the large numbers of chironomids associated with growths of the chrysophyte alga *Hydrurus foetidus* which was more prevalent at C2 than C4 in late winter. The number of dipteran taxa was similar at both sites (16 at C2, 17 at C4).

Trichopterans were numerically the most important order of insects at both sites, accounting for 39% of the total insect fauna at C2 and 60% at C4. These values are much greater than those reported for other Colorado streams (Ward 1975, 1976; Gray and Ward 1978; Short and Ward 1979). In addition, the greatest difference between the aquatic insect communities at C2 and C4 was the differential importance of the Trichoptera.

In a general sense the trichopteran communities appeared similar at both sites. The

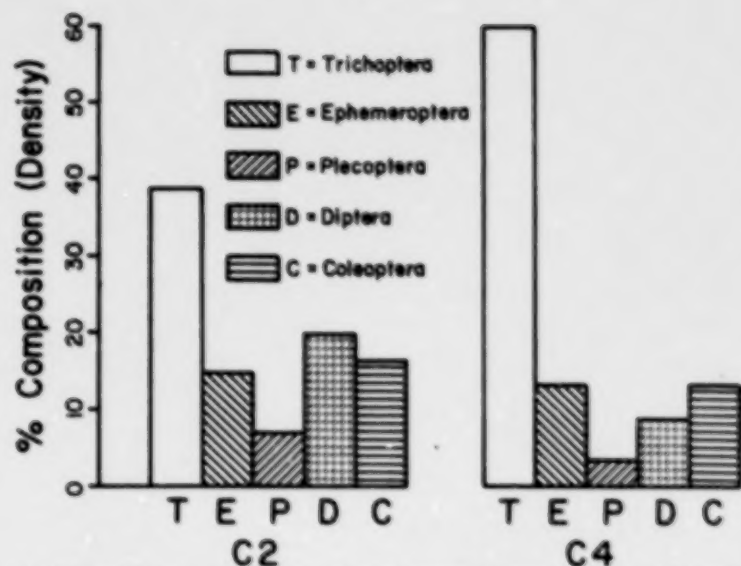


Fig. 3. Percentage composition by numbers of the major insect groups at sites C2 and C4 on Trout Creek, Colorado, over a 2 year period.

density and biomass of caddisflies were greater at C4 (Fig. 4), but these differences were not statistically significant. The number of taxa of Trichoptera was also similar with 12 found at C2 and 11 at C4, 8 of which were collected at both sites. Closer examination of the community structure of the Trichoptera was necessary to reveal differences between the sites (Fig. 5).

Brachycentridae, represented by *Brachycentrus americanus*, exhibited similar relative abundance at each site (15% at C2 and 16% at C4). However, Lepidostomatidae (primarily *Lepidostoma monaka*) was more abundant at C2, comprising 37% of the density of Trichoptera at this site, but only 4% at C4. Glossosomatids (*Glossosoma centrale* and *Agapetus boulderensis*) were abundant at both locations. At C2 they comprised 33% of the trichopterans; at C4 they clearly dominated the caddisfly community with increased abundance of both species, and accounted for 64% of the density. The Hydropsychidae (*Arctopsyche incensis*, *Hydropsyche cockerelli*, and *H. oslari*) were unimportant at C2, comprising only 3% of trichopteran numbers, while at C4, with increased abundance of *Hydropsyche* spp., they accounted for 16% of the density. Hydroptilidae (primarily *Hydroptila*) were relatively well represented at C2, accounting for 6% of caddisflies numbers; however, at C4 they comprised less than 1% of the density.

These differences in the benthic insect community structure of the two sites can be related to relatively minor differences in environmental conditions, in contrast to the extreme perturbations of stream systems subjected to acid mine drainage. The greater development of woody riparian vegetation at the upstream location may account for some of the observed variation. Reduced inputs of leaf litter downstream would explain the lesser numbers of *P. hesumeta* and especially *L. monaka*, since both are shredder species (Merritt and Cummins 1978). The more open canopy at C4, coupled with inputs of nutrients from mine drainage (Canton and Ward 1979), favor certain epilithic algae.

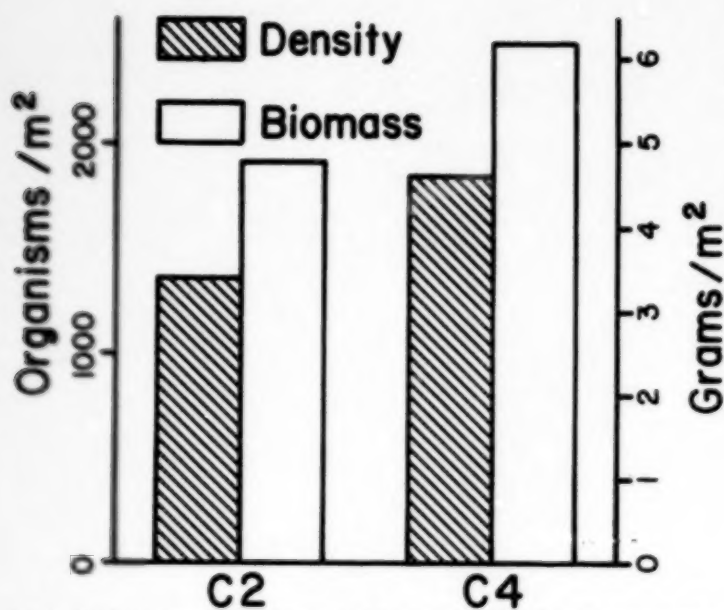


Fig. 4. Mean total density and biomass of Trichoptera for sites C2 and C4 on Trout Creek, Colorado, over a 2 year period.

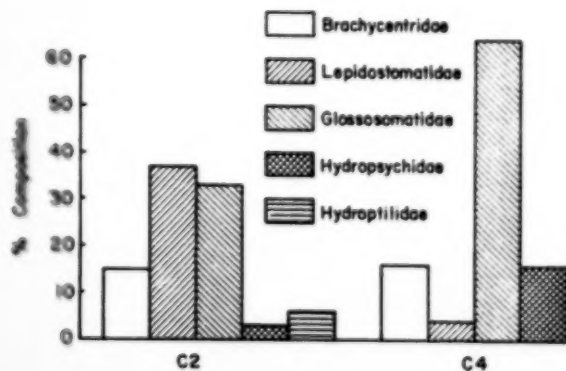


Fig. 5. Percentage composition by numbers of five families of Trichoptera at sites C2 and C4 on Trout Creek, Colorado, over a 2 year period.

The increased abundance of glossomatid caddisflies, which graze on rock surfaces, may be a function of enhanced periphyton production at this site. In contrast, *Hydrurus foetidus*, a slime filament alga, which was much more abundant upstream, had large numbers of chironomids associated with it. Increased hydropsychid populations downstream likely resulted from increases in suspended organics derived from enhanced algal production, irrigation return flow, and grazing activities.

In summary, standing crop, species diversity, and species richness, the tools of general stream surveys, failed to adequately discriminate between the aquatic insect communities of the two study locations on Trout Creek. Only when the structure of the insect community was closely analyzed did the differences between sites become manifest.

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